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Why Are We Writing? This is Math Class!

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Math in the Middle Institute Partnership
Action Research Project Report

in partial fulfillment of the MAT Degree
Department of Mathematics
University of Nebraska-Lincoln
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Why Are We Writing? This is Math Class!

Abstract

In this action research study of my classroom of 8th grade mathematics, I investigated writing in the content area. I have realized how important it is for students to be able to communicate mathematical thoughts to help gain a deeper understanding of the content. As a result of this research, I plan to enforce the use of writing thoughts and ideas regarding math problems. Writers develop skills and generate new thoughts and ideas every time they sit down to write. Writing evolves and grows with ongoing practice, and that means thinking skills mature along with it. Writing is a classroom activity which offers the possibility for students to develop a deeper understanding of the mathematics they are learning. Writing encourages students to reflect on and explore their reasoning and to extend their thinking and understanding. Students are often content with manipulating symbols and doing routine math problems, without ever reaching a deep and personal understanding of the material. My goal through this project was to help students understand why they were doing certain operations to solve math problems. Writing is an essential tool for thinking and is fundamental in every class, in every subject, and on every level of thinking; skills in writing must be practiced and refined, and students must have frequent opportunities to write across the curriculum. Communication in mathematics is not a simple and unambiguous activity.

Teachers should be focused on giving students an education that prepares them for the world they face and the future that lies ahead. Research is abundant on the growth in students' writing ability when writing is incorporated into every hour of their learning day. The answer to the question of who is accountable for teaching students to write is it is no longer just the English teachers. It is *all* teachers. Communication is at the heart of classroom experiences which stimulate learning. Too often in my math classes I see students going through the motions and sometimes getting the correct answer. I have always wondered if students really know why they are going through those motions. Do they understand what the answer means? Do they know why they are performing those operations? When I see my students' writings, I get a better idea of what students do and do not understand. Through my research project, I wanted answers to these questions:

How can I help students see the importance of writing down their thoughts through mathematics?
How can I help improve math skills by having students share their ideas through writing? What effect does journal writing have on a student's conceptual understanding in mathematics?

Right after I started the Math in the Middle program, I began to make my students write detailed solutions to math problems. I found that, for myself, when I wrote my thoughts down into words I gained a deeper understanding of the mathematical content. I began to realize the reason behind performing such operations. I wanted my students to feel the same confidence that I felt when I was a student. I wanted them to understand math, not just go through the motions and pretend to get it. Writing encourages students to reflect on and explore their reasoning and to extend their thinking and understanding. Writing about mathematics gives students the opportunity to participate actively in the learning process.

Just this semester I began to have my students keep a math journal. Journal writing, in my class, was intended to give students another way of communicating their math struggles, concerns, and thoughts with me. Several students took advantage of this opportunity to let me know they needed extra help or to tell me that I needed to reteach a lesson. I also gave several writing prompts that students wrote about in their journals. For example, I might have asked them to explain why one-half was bigger than one-fourth and to give examples of why they thought that way. Through writing prompts, I was able to assess the extent of understanding, or lack of understanding, that existed with my students. The journal writings were an important means of communication between the students and me. Writing develops students' thinking skills and helps them to visualize the material and information.

Problem Statement

I truly want the best for my students, and I want to do my best to help them achieve. My job is to 'prepare them for the future'. Writing in the content area is something I can change, not just something I *wish* I could change. With an increasing number of students that are at different learning levels in our classrooms, it is important for teachers to use methods of teaching that will try to reach all or most levels. Through the use of writing out solutions or concerns, I could see the level of understanding of all students. The advanced students could always take it one step further. My goal for them was to show me their basic understanding, but then to connect the skill to something they are familiar with, something real to them. For the students who normally struggle with mathematics, I just wanted them to write down their thinking so that I could see how to correct them. I just wanted them to see why certain operations were performed in various problems. Once these students understood the meaning behind the problems, they could begin to connect the ideas to something real for them.

When students were asked to write out their ideas and solutions to problems, the whole class realized that there was more than one way to solve problems. This was very beneficial to me because many times I did not know there were that many ways to come up with the same solution. This sparked many great discussions. Students felt good that their ideas counted. In the past, many of my students had teachers tell them one way to solve a problem, and if they did it another way, they had to redo it. Students became more competent in their problem solving skills when they understood that there is more than one way to solve most problems.

Students' ability to question themselves helps them to understand the 'why' behind a lesson. When students are consciously writing down thoughts and steps they have to stop and ask themselves if they are working the problem correctly. When students worked in groups and were asked to write thoughts and solutions in words, the discussions were wonderful for me to hear. They were actually arguing about math! Most of the time, both people arguing were correct, they were just approaching the problems from two different angles. When they both found out they were right, that was always a great teaching moment. I hope that through the experience of writing in my classroom students will have a deeper understanding of mathematics and be successful in future math classrooms.

Literature Review

The National Council of Teachers of English (NCTE) research indicates, "writing is an essential tool for thinking, and if fundamental in every class, in every subject, and on every level of thinking, skills in writing must be practiced and refined, and students must have frequent opportunities to write across the curriculum" (International Center for Leadership in Education, Strategic writing across the curriculum, 2006). Writing evolves and grows with ongoing practice, and that means thinking skills mature along with it.

Shield and Galbraith (1998) studied expository writing of 8th grade students, which is writing that is intended to describe and explain mathematical ideas. The aims of the study were: (1) to develop a method of analyzing the expository writing of mathematics students in order to provide a coding scheme for the description of the content of the writing; (2) to formulate a general model of the expository writing of the students in the study and to compare the model with the writing of the textbook used by students; and (3) to use the description of students' mathematical writings to provide an indication of the understanding of particular mathematical ideas held by the students. Journal writing was intended to assist students to see themselves as active agents in the construction of mathematical knowledge. This is what they said about writing tasks.

It has been argued for many years that the use of writing tasks in mathematics learning should promote a deeper understanding of mathematical ideas. ...The writing products of students in schools appear to be constrained by the models of mathematical presentation to which they have become accustomed. It will be a long term task for teachers of mathematics to increase the meaningfulness of their students' mathematical writing in a way which promotes a higher level of thinking about the ideas (Galbraith & Shield, 1998, p. 29-52).

The significance of this study is that it points to modes of communication as indicative of stances toward learning mathematics and ultimately how students see mathematical knowledge. Writing is thought to promote a personalized and constructive approach to learning. When students write out their mathematical thoughts on paper, the teacher and other students can see the thought process. If there is a mistake in the problem, someone can look back at it and catch where the problem is located.

The main struggle I had with this project was getting my students comfortable with writing in mathematics. This was something new and out of the ordinary for them, but I feel that they became comfortable with the idea, and they saw the importance of writing in the math

classroom. I wanted to show that writing reveals the students' conceptual understanding, students' strategic competence, and students' adaptive reasoning. I wanted all of my students, no matter what their ability level, to be successful in math class.

Baxter, Woodward, and Olson (2005) studied and analyzed how one teacher used writing to support communication in a seventh-grade, low-track mathematics class. For one school year, they studied four low-achieving students in the class. Using classroom observations and interviews with the teacher, they developed profiles of the four students, capturing their participation in class discussions. The purpose of the study was to examine what writing revealed about low-achieving students' mathematical proficiency.

Perhaps the greatest promise of writing in mathematics is that it will forge connections with students who typically drift or run rapidly away from mathematics. Writing offers a means for students to relate mathematical ideas to their own lives. Writing can be seen as providing an opportunity for more students to engage in making sense of mathematics (Baxter, Olson, & Woodward, 1993, p. 132).

This article's study of journal writing raised both concerns and benefits for instructional purposes. As the students in the study wrote about familiar mathematical ideas, the teacher was able to read students' responses and develop a more complete picture of what the students did and did not understand. When students show their thought process, it is easier for teachers to follow and see mistakes or misinterpretation of mathematical ideas.

Writing about mathematics gives students the opportunity to participate actively in the learning process. Students should become comfortable with demonstrating their understanding through reading, writing, listening, and speaking. When I read my students' journals, it brings me to the realization of who understands the material and who does not. Math usually is not every student's favorite subject. Many students have had bad experiences in the past with mathematics concepts and/or instruction.

“Most mathematics students seem to interpret their role as essentially acquiring (e.g. memorizing) facts and algorithms that can be applied to the solution of given exercises; few students expect mathematics to be meaningful, and fewer still see mathematics as a creative undertaking” (Borasi & Rose, 1998, p.347).

I did not want to see my students struggle. I wanted them to feel comfortable communicating their struggles to me. Journal writing accomplished that for many students in my classroom. Writing should never be done for the sake of doing so, but should be used to achieve a definite goal. Students should feel challenged and yet be able to be successful in achievement. Writing develops students’ thinking skills and helps them visualize the material and information.

This research project differs from the published literature in several ways. For instance, this research involved middle school students, while the students in the literature were predominantly elementary students, with one study focusing on high school students. Also, while this research investigated written communication (journal writing), most published research instead investigated the written work of students expressing their mathematical processes to solve problems. This research study was conducted for a semester, while the studies in the literature continued for an entire school year or multiple years.

Purpose Statement

Students have a difficult time communicating mathematics in a written form. Because of my involvement in Math in the Middle, I have realized how important it is for students (me included) to be able to communicate mathematical thoughts; this helps with deeper understanding of the material. I have seen, too many times, students who go through the motions. When I ask students why they perform certain steps to solve problems, and they can’t tell me or they say, “Because that’s how you do it”, I know I have failed them. If students do not

understand why they are following certain steps, they are not learning. When students cannot connect mathematics to something real to them, an example from the outside world, then they are not learning. If students do not understand the material well enough to teach it to someone else, they are not truly learning.

The purpose of my study was to help students communicate mathematics effectively through writing. I wanted to see an improvement in conceptual understanding through the use of various writing activities. I wanted students to slow down and think about the steps and the ‘why’ behind their steps. I wanted students to be conscious of what they were doing, not just writing down a bunch of numbers. For students who do not feel comfortable addressing their difficulties in a large group, individual writing to the teacher sometimes helps them open up and express where they are having trouble. I wanted verbal communication to improve also with the use of written communication. Through the variables of expository writing and journal writing, I hoped to answer the following research questions:

- *How can I help students see the importance of writing down their thoughts in mathematics?
- *How can I help improve math skills by having students share their ideas through words?
- *What effect does journal writing have on student conceptual understanding in mathematics?

Method

I started collecting data with a teacher journal, starting on February 6, 2007. I wrote in my journal at least once a week, mostly when my students were assigned a writing activity. I reflected on their thoughts and reactions to writing prompts and journal entries. The journal also helped me keep writing prompts. I used a book called Write About Math by Richard Piccirilli. There were great writing ideas in there. When I see the majority of the class struggling with a concept, I made a note of that, and it will help me know what to focus on in the future. My last

teacher journal was written on May 21, 2007. The journal was a great way to keep notes on how the whole class was grasping the content.

I gave a student survey on February 28th, and again on May 21st (see Appendix A). I wanted to find out how comfortable they were with writing in math class. I wanted to see if they thought that writing solutions to math problems in words would help them understand math concepts. The surveys were kept in a file, and I compared responses after the second survey.

Students kept a weekly journal. Every Friday, I asked the students to ‘sum’ up their week. The journals started February 9th and continued until May 21st. I wanted them to recap what they had learned in my class. I asked them to communicate their thoughts and concerns to me. This was most beneficial to me. As I read the journal entries, I commented back to them. The lines of communication really opened up. I gave each student a ‘mini’ notebook that was only used for their written work in my class. When students walked into my room every day, they had a problem or problems presented to them. The problems might be a review from the day or days before, they might be new material, or there might be a writing prompt that they needed to respond to. If the students are asked to solve a simple problem, they did not use their ‘mini’ notebooks; they had separate notebooks for that. At least once a week I presented them with a writing prompt. Students had to write at least three complete sentences to share their thoughts. I stressed grammar, punctuation, and spelling. After they were done writing, we had a class discussion so if they struggled they could get an idea of what to write.

On daily assignments, I often asked students to write out the solution to one problem in words. I started out doing this daily, but toward the end of the year it was weekly. I started asking them to write out solutions February 5th. I gained an understanding of which students knew what they were doing and which ones were going through the motions. I started out

demonstrating the writing activities with the whole class. I wanted them to know exactly what I expected. For two weeks, starting in February, I wrote out the solution to a problem with each class on a daily basis. This helped students feel more comfortable with the writing process.

I interviewed students on April 25th (see Appendix B). I wanted to interview them twice during the semester, but with state assessments, time ran short. I was so pleased with interview answers. Students did not seem to hate writing and, for the most part, they understood my purpose for having them write. The students said that writing helped them gather their thoughts, and it showed me what they understood and what they did not.

I did run into conflicts with data collection. At the 8th grade level, there are six state tests that need to be administered. This year, our school decided to write our own tests. This meant time spent away from the classroom. As we wrote the tests, we decided to write multiple (four) versions of each standard (so, 24 tests total). This meant that students had up to four chances to prove proficiency on a particular standard. This worked well, but time was an enemy. On top of taking time out of the classroom, it took five weeks to complete the testing process. The students still wrote in their journals, but as far as writing solutions to problems in words, that was put on hold. At the beginning of May, our students took another assessment, the Northwest Evaluation Association (NWEA) Measures of Academic Progress (MAPS) test. This took three days of class time. Bus evacuation (practice), fire drills, tornado drills, assembly, musical, and speech presentations all took away class time. Teachers have to be very flexible to work with so many interruptions in the middle school.

Findings

Students did a great job of answering my journal prompts verbally, but putting thoughts into words was difficult for them. Students wrote thoughts and ideas about the math material in

general, but when it came to writing specific steps and processes, they had difficulties. Students wanted me to tell them answers, rather than thinking for themselves. Most students understood how to do the problems, and most of the time they could explain their thinking to me or anyone else orally, but written communication was difficult. By looking at their daily assignments and reading their responses to written questions, I saw that they were getting more familiar with the writing process over time. I saw more complete sentences, and the grammar improved. From the surveys I saw that students did not like to write, and some of them did not understand why I wanted them to explain their thoughts to me. As I read journals and daily assignments, the students were more comfortable within a couple months with the writing process in math.

Students were initially uncomfortable communicating math through writing because it is out of the norm. Most math teachers in my school district do not make students use a lot of words in math. Now that students came to 8th grade and I made them write, it was difficult for them to change. From reading the journal entries made on Fridays, I saw that students were asking me questions that they did not feel comfortable asking in the large group. From the teacher journal I saw that students were stopping to think through their thoughts and process more than they did at the beginning of the year. From student work, I saw that they took more time to think about the problem and answer before they wrote.

My students have always had a difficult time thinking for themselves. I think that for so long, my students have been told what to do, and I asked them to think for themselves, it was difficult for them. Giving students a writing prompt to write about gave them a chance to think through the process and not just give answers. This process took time. Through the semester, they opened up to me more and more. Because I wrote comments back to them, they realized

that I really read their responses, and they were able to ask a question they were not comfortable asking in front of the class.

Students did not complain as much when I asked them to write out solutions at the end of the semester compared to the beginning. The only pattern I saw from the data that I collected was that students had a hard time expressing their ideas in written words. Writing out thoughts definitely helped me pick out the students who understood the material and the ones who did not. By reading the journals, I got to fix the problem before it was too late. When they told me what they struggled with or if I saw a problem they did not know how to explain from a writing prompt, I got to step in and make corrections. This was a powerful tool.

My first research question was: How can I help students see the importance of writing down their thoughts in mathematics? Interviewing the students, having students participate in journal writing, and writing a teacher journal helped me gain insight into this question. The majority of them told me that when they write out solutions they slow down and think through the process before they write. They understood that this was a tool for me to see who truly understands the concept. One student said, "I like showing my work so you can help me find my mistake."

When I presented students with a writing prompt, I easily saw problems or concerns the students had with the mathematics. If I saw a student who had a good understanding because they explained it thoroughly in their writing, I paired him or her up with a student who did not seem to have a grasp on the material. By writing in my teacher journal, it helped me to gain a bigger perspective on what areas I left out when I taught the material. Several times the students gave me ideas on how to approach certain topics. On March 22, 2007, I asked the students to explain in words how they knew whether to use the inside or outside numbers on a protractor. I

taught a short geometry section and assumed that students were comfortable using a protractor, so I decided not to spend a lot of time instructing them. As I walked around the room on March 22, this is what I observed:

Today's writing prompt was to tell me how you know whether to use the inside or outside numbers on a protractor. I think students know acute and obtuse angles, but they have no problem putting 175 degrees as an answer for an acute angle on an assignment. Students could explain the writing prompt (journal) to me out loud, so I told them to write exactly what they said, and they struggled. I get the feeling that I shouldn't assume that my students are proficient in the use of a protractor. Students had a hard time finding the right thing to write today. (Teacher journal, 2007)

In a student journal I read, "Writing really is not as bad as I thought. Writing helps me to gather my thoughts and not work so fast through a problem. When I take the time to write solutions, I think more about what I'm doing and I make less mistakes." This quote is important to my research to confirm that writing in mathematics is necessary. Some students could see the validity of writing out their thoughts to mathematical problems or statements because the process was real to them. The students were not just following a set of rules anymore; they were thinking through the process and making sense of the problem.

My second research question was: How can I help improve math skills by having students share their ideas through writing? When I first asked students to write out the solution to a math problem on an assignment, the class looked at me like I was crazy. I heard the comment, "Why are we writing? This is math class! We do plenty of writing in Language Arts!" I modeled this daily for two weeks. After that two weeks I believe my students improved in their math skills. For the first time many students had to stop and think about the process. I made comments on their papers and often this brought about wonderful classroom discussions. It did not take them long to realize my purpose behind making them write: to gain a deeper understanding of the material and to show me that they knew what they were doing.

From their student work and their journals, I saw that they took more time to think about the problem and the answer before they started to write. The students stopped to think if the answer made sense, and they asked themselves why they were doing it. From their journals, the students expressed concerns about concepts they did not understand. Many students did not know how to ask a question in class, but their journals gave them a way to communicate directly with me. For example, a student wrote in her journal, “Miss Streeks, I really don’t understand reflecting shapes across the x and y axis. I can see a picture in my mind, but the process doesn’t make sense to me. I am trying to memorize, but I need extra help. I don’t feel comfortable asking this question in front of everyone, they will think I’m stupid.”

My third research question was: What effect does journal writing have on student conceptual understanding in mathematics? I had two purposes for my journals. One was for students to comment on various writing prompts and the other was to voice concerns and struggles to me. The writing prompts were fun! Students had to take real life situations and write their thoughts using math skills. Dialogue in my classroom was exciting. Again, through student interviews, I heard how students perceived writing as helping them think about the processes and not just writing down a bunch of numbers.

Student journals helped me to see whether students completely understood a topic or not. For example, one Friday I wrote a prompt on the board: Why do the exterior angles of a polygon add up to 360? This prompt was intended to sum up a week lesson on interior and exterior angles of polygons. I wanted to see if students could extend their thoughts about the sum of angles in a polygon and their background with supplementary angles. These are the thoughts of one of my students:

A polygon has three or more sides. The sum of the angles in a triangle is 180. If I look at a 60-60-60 triangle, I can extend the sides to form two adjacent angles at each vertex.

This forms supplementary angles. Supplementary angles are two angles that when added together equal 180 degrees; they form a straight line. So, the outside angles are 120,120,120. If I add these together, I get 360. Wow! I might have figured it out. The more sides a shape has, the closer it looks like a circle. A circle has 360 degrees. I drew a bunch of pictures, so you will have to look, Miss Streeks (Student at my school, 2007).

From reading the journal entries made on Fridays, I saw that students were asking me questions that they did not feel comfortable asking in a large group. From my teacher journal, I saw that the students were stopping to think through thoughts and processes more than they did before. The interviews showed me that writing in math has helped students to better understand certain concepts. The student interviews were interesting, and a few students commented that all classes should mix material better, doing all subjects in all classes. The students think it is important to be able to read and write in every subject. As I read the student journals and daily assignments, students were more comfortable than a couple months ago with the writing process in math.

Conclusion

When students write in mathematics, they can be encouraged to express and reflect upon their feelings, knowledge, processes, and beliefs about mathematics. Writing tasks in mathematics learning should promote a deeper understanding of mathematical ideas. Communication is at the heart of classroom experiences which stimulate learning. Research indicates that when writing is emphasized and taught in every class, student achievement on state assessments and other measurements greatly improves. Students who are competent and comfortable in writing skills will demonstrate growth in core academic learning. Writing evolves and grows with ongoing practice, and that means thinking skills mature along with it. Teachers help students focus on critical thinking when they ask students to write in mathematics. Writing

skills help students respond at an advanced level of insight and comprehension, so the time spent on writing is a great benefit to the overall learning process.

Writing improves student understanding, and gives students a voice. To become comfortable with math, students should read, listen, reflect, discuss, and write about mathematics. As they process their thoughts in words, students discover new approaches to working with numbers.

Implications

I will continue to learn more about writing in the content area of mathematics. I will continue to spread the word in my district about the importance of writing in all content areas. I want other teachers to be able to connect with their students the way I have. I have opened the lines of communication with my students, and I want other teachers to do the same. I do not want students to continue to struggle in math. I want to find out where their struggles lie and be able to help them through. I love using student journals. Writing prompts will definitely be used at least once a week in my classes. Students will continue to write out solutions to math problems on their homework. Written communication will be a part of my every day lessons. Writing is a classroom activity which offers the possibility for students to develop a deeper understanding of the mathematics they are learning.

I strongly advise teachers to emphasize the importance of students writing mathematical thoughts in words. When I began this project, my main concern was time. Would I have enough time to emphasize writing and get through my curriculum? When students walk into my room, a mathematical question is posted on my board. This may be a math problem that students have to write the solution for or a math prompt for which students are asked to write three complete sentences. Students keep these thoughts in a journal and take no more than three or four minutes

at the beginning of class. When everyone has had time to think through the problem, we discuss it as a class. Most of my students start their journal before the tardy bell rings, so the entire process takes five to seven minutes of class. For those students who did not know how to answer the question, class discussion probes them to write thoughts in the journal.

During daily assignments, I ask students to write the solution to one problem in words. Students must use complete sentences and express all of their thoughts in words. The first couple weeks of my research were difficult, and it took time for me to model my expectations. Once students knew what I expected, they became comfortable with the process and writing out solutions took students only a few minutes. In the end, having students completely understand a topic paid off. I did not get to teach linear equations in depth as I would have liked, but having students show me that they understood what a solution to an equation means was beneficial. I feel that my students have a deeper understanding of basic concepts. Students have a stronger base to build on if they understand the basics. Mathematics builds on itself.

Student journals are a good way for teachers to make sure everyone in the class is 'on the same page'. There were days when student comments and written work told me that I needed to re-teach that concept. Open communication between the teacher and student provides a positive learning atmosphere. If students feel comfortable asking questions, whether in class or through a journal, concepts will make more sense.

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Appendix A

Math Survey

Please give your honest response to each statement.

Circle a number to best answer each question- 1 being low and 5 being high.

	Low				High
1. I enjoy writing.	1	2	3	4	5
2. I like math.	1	2	3	4	5
3. Writing solutions in words helps me to understand math concepts.	1	2	3	4	5
4. Writing skills are important in all classes.	1	2	3	4	5
5. I am able to express my math ideas in words.	1	2	3	4	5
6. I feel comfortable writing in math class	1	2	3	4	5
7. Journal writing in math helps me communicate with the teacher.	1	2	3	4	5

Complete the following statements:

8. Are math concepts easy for you to explain in words? Explain.

9. Do writing prompts help you communicate your math struggles to the teacher? Explain.

Appendix B

Student Interview Questions

1. Why do you think I ask you to write in math class?
2. What is the purpose for the journals and writing prompts?
3. Do you like writing?
4. How do I know when you really understand a math concept?
5. Does the journal writing help you communicate your struggles with me?
6. What are the benefits to writing out solutions to math problems in words?
7. How successful do you feel about writing in math class?
8. Do you enjoy math?
9. Do you enjoy writing?
10. What would make math easier for you?
11. Why is it important to write in math class?
12. Has your attitude about writing in math changed since the beginning of the year?
13. Are there any questions you have for me?
14. Is there anything else I should know about you to better understand your struggles in math besides communicating through writing?